Appendix D - Outline of Technical Responsibilities for International Partners

At this time there are no formal agreements in place for international partnerships and associated responsibilities. We have a stated openness to multi-agency participation within the U.S. and to foreign contributions to the mission. Within the U.S. we have team members already supported by funding from NASA, Smithsonian, DOE, NIST, and NSF.

On the international side, our approach to date involves substantial international participation in the Facility Science Team (FST) and in several of the technology development efforts. The FST oversees the scientific aspects of the mission during its formulation stages. It is comprised of approximately 50 scientists from 30 different institutions and 5 different countries (U.S., UK, Denmark, Italy, and Japan). FST scientists from outside the U.S. have been heavily involved in technology work on the Spectroscopy X-ray Telescope and the Hard X-ray Telescope mirrors. Non-U.S. companies are providing glass for technology efforts on both sets of optics, mandrels for the SXT, and masters for replicating off-plane reflection gratings. At this time we advocate open exchange of ideas and discussions of approaches and progress (as well as challenges) without formally obligating NASA or the Constellation-X mission to any formal teaming arrangements or financial commitments. It is our intent that decisions be driven by performance demonstrated during the technology studies and by open competition through the AO for science instruments.

As we proceed, there will be natural opportunities for international collaboration. Our approach to the SXT mirror draws heavily on the ESA experience with replicated optics for the *XMM-Newton* mission. There are also similarities in our SXT requirements and the optics for the ESA XEUS mission (although the XEUS requirements are more demanding). There have been ongoing discussions about possible closer collaboration on the mirrors, but at this time substantial differences in programmatic approaches and limited ESA funding have limited collaboration to exchange of ideas. We have agreed to revisit possible ESA (or individual European country) involvement in the SXT mirrors over the next 1-2 years. Possibilities range from provision of the mandrels ($49M RY), to mandrels plus finished reflectors ($91M), to mandrels plus reflectors plus mirror assembly and test ($147M).We are also keeping tabs on totally different technical approaches in Europe (and in the U.S.) which deliver additional SXT performance at comparable cost to our current baseline approach. Success in such developments on the European side would no doubt spur further discussions about additional ESA or European involvement (perhaps from Germany and Italy), since it would make contributions more meaningful to those involved. At the least, we will have the option of using U.S. Constellation funds to procure optics (or other hardware) with enhanced capabilities from non-U.S. vendors if that proves in the best interest of the project.

For the Hard X-ray Telescope there are equally interesting possibilities. Our Italian collaborators at OAB have already stated an interest in providing the HXT optics using Italian Space Agency funding. Their approach is using silicon carbide carriers with replicated shells and multi-layer coatings to produce the optics. While there is not a formal commitment in this area, that is at least in part due to our stated intention to continue technology developments to the point where performance is demonstrated at the required level, enabling us to make decisions which are driven by performance as well as cost considerations. HXT optics if provided by Italy would represent a contribution of $35M to the Constellation-X program. There is also a possibility of Japanese involvement in the HXT. Japanese team members have developed segmented aluminum with multi-layer coatings for HXT-like optics and might be interested in providing these for Constellation-X at a similar cost value to the Italian HXT optics, assuming these metal optics can meet the HXT requirements. One approach would be to negotiate participation of an international partner and formalize the agreements in a LOA or MOU as described in Appendix C.

In addition, non-U.S. groups almost surely will compete for one or more of the Constellation instruments - X-ray Microcalorimeter Spectrometer, Reflection Grating Spectrometer, or HXT optics and detectors. If such a team is successful under the AO, the value of their contribution (in non-U.S. funds) to Constellation-X could range from approximately $55M to $130M.